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(54) Title: PROTECTIVE FIBERBOARD TO PROTECT ELECTROSTATIC SENSITIVE DEVICES FROM STATIC ELECTRICITY

(57) Abstract

Fiberboard to protect sensitive electronic components and devices from the hazards of ESD (electrostatic discharge) incorporates a homogeneous shielding paperboard (30, 33) to less than or equal to one thousand ohms resistance that has been (28, 32) adhered together throughout the corrugation process or lamination process with one or more homogeneous colored dissipative high strength linerboards (34, 35). The liners have a surface resistance range between a targeted one times ten to the seventh ohms through one times ten to the eleventh ohms at twelve percent relative humidity and seventy three degrees Fahrenheit. The linerboard (35) or paperboard (30, 33) can be used as static safe packaging cushioning material, shelving liners, dividers, in-plant handlers, specialty static free packaging, and dissipative or shielding paper bags.

PROTECTIVE FIBERBOARD TO PROTECT ELECTROSTATIC SENSITIVE DEVICES FROM STATIC ELECTRICITY

FIELD OF INVENTION:

This invention relates to the field of protective packaging for electrostatic sensitive devices and specifically to an improved fiberboard for use in such packaging and a method for making the improved fiberboard.

BACKGROUND OF INVENTION

DESCRIPTION OF PRIOR ART:

Static electricity is a significant concern in the packaging, handling, manufacturing and distribution of electronic components and computer sub-assemblies. ESD (electrostatic discharge) damage is estimated by the ESD Association to cost the electronics industry upwards of $4,000,000,000 annually.

Today's printed circuit boards that are comprised with electronic components, are very sensitive to static electricity. Advancements in technology over the past 30 years have miniaturized electronics circuitry to the extent that one of today's quarter- sized microprocessors easily has more combined power than large rooms filled with super computers of Sandia Labs, New Mexico of the 1950s.

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Static electricity is caused by trioboelectric charging (two charged objects which generate friction upon contact) that discharges to a conductive or grounded surface. On a larger scale, clouds come into contact with one another and the imbalance of negative and positive ions causes a lightning bolt or high voltage discharge to ground. On the microscopic level, an insulative object could rub against another object to cause an ESD discharge. A relationship between the relative humidity and potential for ESD events can take place anywhere in the world. Any area is a candidate for static electricity at one time or another. In Southern California, the Santa Ana winds will promote a dry environment and cause countless discharges as one comes into contact with a car door handle or simple electronic circuit board. For instance, the potential for a static event is evident in Colorado where the relative humidity drops below 4% in winter. Insulative surfaces have a greater tendency to hold a charge versus grounded conductors. For example, the following table illustrates the voltage generated on objects at specific relative humidities.

VOLTAGES FROM CHARGING MILITARY-B-HANDBOOK-263

	20% RH	80% RH
WALKING ACROSS VINYL FLOOR	12KV	250 V
WALKING ACROSS SYNTHETIC CARPET	35KV	1.5KV
ARISING FROM FOAM CUSHION	18KV	1.5KV
PICKING UP POLY BAG	20KV	600V
SLIDING STYRENE BOX ON CARPET	18KV	1.5KV
REMOVING MYLAR TAPE FROM PC BOARDS	12KV	1.5KV
SHRINKING FILM ON PC BOARDS	16KV	3KV
TRIGGERING VACUUM SOLDER REMOVER	8KV	1KV
AEROSOL CIRCUIT FREEZER SPRAY	15KV	5KV

The ESD damage which can occur within a very small fraction of a second can be highly visible causing problems immediately or can takes years to be detected. Consequently, latent failure could take place causing a product to work 50% of the time or on an erratic basis which is known in the industry as a case of the "walking wounded". This static electricity damage can be extremely costly due to product image, customer returns, and wasted materials and labor.

Perhaps the most tragic incident of discharge occurred in the 1960s, at Cape Canaveral resulting in the death of three astronauts. This incident was attributed to a static discharge of ignition to the rocket motor squib. A NASA test method to test materials for triboelectric charge generation and decay was developed as MMA-1985-79-REV 2 July 15, 1988 RH Gompf, PE, Ph.D. NASA

& C.L. Springfield, NASA Chief Materials Testing Branch. Insulative materials would no longer be able to come into close contact with the space vehicles. The following table outlines the electrostatic voltages than can damage electronic devices.

SUSCEPTIBILITY RANGES OF VARIOUS DEVICES

EXPOSED TO ESD CHARGES

DEVICE TYPE	RANGE OF ESD SUSCEPTIBILITY
M.R. HEAD® TECHNOLOGY	5-50 VOLTS
MOSFET	100-200 VOLTS
JFET	140-10,000 VOLTS
CMOS	250-2,000 VOLTS
SCHOTTKY DIODES, TIL	300-2,500 VOLTS
BI-POLAR TRANSISTORS	300-7,000 VOLTS
ECL (FOR HYBRID USE/PC BOARD)	500 VOLTS PLUS
SCR	600-100 VOLTS

Due to volatile fuels and the potential for explosions on ships and aircraft, the Department of Defense in the late 1970s set standards to protect products and people from the hazards of ESD. The focus was in relationship to handling, storage and packaging of ESD sensitive products. The rush was on to develop materials that would protect sensitive components and devices from static

electricity. Conductive enclosures were found to provide a path to a grounded surface and reduce the hazards of triboelectric and high voltage discharges.

In the area of packaging, foil laminated to various forms of paper was found to shield against static electricity when the object could be enclosed. An electrically conductive enclosure or box-like configuration known as a Faraday Cage was found to attenuate or shield objects from static electricity. Later, carbon loaded polymer totes and nickel metalized 3M® shielding bags were known to exhibit shielding properties.

PAPER DEFINITIONS:

Kraft is of German origin meaning strength; designates pulp, paper or paperboard produced from wood fibers by the sulfate process. One type is cylinder kraft containerboard, which is a multi-ply formation with predominate grain direction of fibers made from a natural light brown like kraft pulp on a cylinder machine. This type of paper making technology is widely used. Corrugated is the accurate term for "cardboard" box liner(s) and medium that has been bonded together by a corrugator. Fiberboard is a general term describing combined paperboard (corrugated or solid fiber) used to manufacture sheets or containers. It can take two or more paperboard liners and be adhered to a fluted corrugated medium to form corrugation or be of a makeup of two or more paperboard liners that through lamination will form solid fiber or a folding

carton material. Boxes are formed fiberboard. Paperboard includes the broad classification of materials made of cellulose fibers, primary and recycled wood pulp, recycled paper stock, newsprint, packaging papers, solid and chipboard fibers that can be made into boxboard,, chip board, solid fiber or fiberboard. Containerboard is the paperboard components (linerboard, corrugated materials and chipboard) used to manufacture corrugated and solid fiber. Medium is a paperboard material that has been formed into a wave shape or flute structure and is usually buried between one or more linerboards. Linerboard is the paperboard used for the flat outer facings of combined corrugated fiberboard or laminated as the outer facings of fiberboard.

Although corrugated natural kraft (cardboard) boxes were found to be antistatic or static dissipative at higher relative humidities, the kraft paper was not electrically conductive enough to provide the necessary static shielding. Kraft paper is hygroscopic (absorbs water) and the porosity of the surface can make paper dry out in low relative humidities below 23% to 30% for bleached white and below 12% to 15% relative humidity for kraft paper; thus,. the material exhibits insulative characteristics. It will not drain a charge to ground nor prevent a charge from being generated. High areas of electronic manufacturing such as California, Colorado, Arizona, Texas and other states, have problems with low relative humidities. To complicate the issue, air transit of conductive components will cause the packaging to be exposed to conditions in very low

relative humidities. Military Standard 81705 is required by some electronic organizations to evaluate corrugated materials in adverse transport conditions. Specimens are placed in a dry oven for 12 days at 160^{0}F and conditioned in a chamber for 48 hours at 73^{0}F +/- 6^{0}F @ 12% +/-3% relative humidity (Standard Conditions for ESD Association). Then the material samples are tested for surface resistance per ESD-S.11.11-1993 in ohms. Kraft paper in itself would not pass ESD-S.11.11-1993 @ standard conditions since paper has been known to exhibit various cut off limits in low relative humidities.

Another problem is that kraft roll stock is traded between companies and depending upon the amount of virgin fiber that has by definition been pulped in the sulfate process, the paperboard may have too much reducible sulfur in amounts that exceed eight parts per million per TAPPI 406 om-94. Sulfur can act as a corrosive to electronic devices that could come into contact with the kraft liner. The cut off for static dissipative materials as measured for surface resistance on an insulative plane is 1.0 x 10^{11} ohms and 1.0 x 10^3 ohms for static shielding conductive surfaces. One of the first primary approaches to make conductively shielding corrugated was to coat kraft exterior liners or corrugated with a conductive carbon ink which exhibits a surface resistance of 1.0 x 10^3 ohms for the base coat or coatings. A second or third coating of clearcoat varnish is applied over the carbon ink to reduce rub off (Patent numbers: 4,160,503, 4,211,324 & 4,293,070). Due to wear, the carbon particles can rub

off and bridge the gap of PC board circuit lines and cause a short. The material with a kraft medium, which is arched, and the kraft liner can prevent a drain to ground in low relative humidities per Electronic Industry Association, EIA-541 Appendix F. In this method +/-1000 volts to +/-100 volts is required to drain to ground in less than 2.0 seconds. Such a material has a very conductive surface resistance that can exhibit "sparking" or a rapid discharge if the container is in an open state and placed on a grounded surface. This type of discharge is known as a Charged Device Model hazard. However, a subsequent technology developed with a basis weight of 42 pounds per thousand square feet (lbs./msf) or 69 pounds per msf. Patent number 5,407,714 is composed of taking a kraft liner and printing the back side of the inner kraft liner with a highly conductive static shielding carbon black ink. Consequently the ink is buried beneath the kraft liner and adhered to a kraft corrugated medium. The kraft liners are coated with a blue or black dissipative surface with a clear coat dissipative sealer to the exterior. The medium is conventional kraft paper as found in most boxes. This product has been observed to delaminate between the fluted medium and the interior ink conductive coated liner. From samplings, it appears that the coating process of the reverse side of the kraft liner compromises the adhesion process between the medium and the liner interior facings. The corrugated medium is less able to bond to a coated surface as compared to a kraft uncoated surface. Consequently, the liner separates with relative ease. The material is CDM safe and shields very well. The exterior coat

of the kraft paper liner is still blue or black coated while the interior or back side of the liner is conductively coated. The liners are corrugated to a kraft medium.

One of the first layered technologies to consider CDM safety is patent number 4,000,790. It has 6-7 recycled layers of recycled paper that is produced on a cylinder machine. The paper weighs about 54 pounds/msf to 69 pounds/msf. The kraft wood chips are layered down and the layers are built-up. The fifth or sixth buried layer consists of carbon black to provide shielding against static electricity. The carbon bleeds through the other layers in less amounts. Thus, the surface becomes dissipative. A final polyethylene coating is used to reduce severe rub off of carbon particles as found with conductively coated ink liners which could bridge the gap of circuit board and cause a short. However, after use, the lesser amounts of carbon on the surface may still be a means to cause a short. Another cylinder CDM safe material is being commercially sold under patent number 4,711,702. The product is a very similar technology to the above but the material has shown to have less internal bond in the layers (weight: about 48 pounds/msf) and the inside portion of the liner is more like kraft. Corrugated with kraft medium may pose a problem with suppressed charges or hidden charges known as "Crypto" charges that can develop in lower relative humidities. In addition, taking a flat piece of the corrugated board and subjecting it to a static decay from +/-1000 volts to +/-100 volts at standards conditions could exhibit a decay of more than 2.0 seconds.

Patent number 5,205,406 laminates a thin metalized highly conductive film to chipboard, solid fiber or kraft liner. The metalized layer is coated with a low density polyethylene film which is subjected to high energy electron beam radiation. The surface is dissipative and the metalized film is conductive. The material shields very well but it has been observed to have a slow drain to ground at standard conditions with the solid fiber material. The paper that is sandwiched between the laminated liners has been observed to have difficulty in draining charges away in less than 2.0 seconds. Some samplings of the material as they have been repulped to determine repulpability have contained metallic particles. The original versions of foil laminated corrugated have not been in wide use due to the problems associated with repulpability.

Patent number 5,637,377 utilizes an impregnated conductive medium that is cohered as corrugated medium between two blue kraft coated liners that have been preprinted with two coats of an ink composed of carbon and blue copper dissipative ink. Preprinting the liners assists in the uniformity of electrical surface readings by an even application of the ink and varnish over the kraft liner. A final coating of styrene acrylic polymer or clear coat varnish is printed in two passes onto the drying blue ink. Due to wear and rub off, the conductive particles used in the formulation of the above exterior dissipative liners of this product may be sufficient enough to bridge the gaps of a circuit and cause a short. Wear and

tear will eventually expose the kraft liner which could become insulative in lower relative humidities. Their other version appears to use untreated or standard cylinder kraft paper. If one sampling of the kraft paper is virgin paper, the material may exhibit higher degrees of reducible sulfur contamination than recycled paper. The untreated liner has a severe set back in not being able to maintain static dissipative properties in lower relative humidities below 12% to 15%. The difference in readings may stem from the variance of kraft liner sources that are widely used in the corrugated industry. Linerboard designated for produce or food packaging could be corrugated into this material. The preferred method as employed by the other technologies in corrugated boxes with one side being static dissipative with a kraft medium and the other side being coated or layered conductive technology or buried shielding in the outer liner cylinder technology is to position the ESD liner on the inside of the box while exposing the kraft liner to the outside of the corrugated box or container. Static shielding has been observed to be improved as measured by a high voltage discharge test method. During transport on land, sea and air, the relative humidity can drop to less than 4%. Consequently, an untreated kraft liner would act as an insulator and triboelectric charging could occur by the vibration or movement in transportation where a charge transfer could take place. The electronics industry could use a carbonless Charge Device Model (CDM) safe material that has a buried homogeneously static shielding medium. The material would be volume resistance (providing an excellent path or drain to

ground), offer a variety of printing options, repulpable, static shielding, gluable and able to form into various combinations. The invention represents such an ideal technology.

OBJECTS AND ADVANTAGES:

Accordingly, several objects and advantages of my invention are superior static shielding of electronic components due to a highly conductive buried medium. Unlike other prior art technologies, this invention is a CDM safe material that is humidity independent while exhibiting superior static shielding, carbon free static dissipative surface liners, and volume resistance. The volume resistance of the fiberboard offers protection from hidden charges or "Crypto" charges. This is a very important benefit since the paperboard is homogeneous to promote an electrical path to ground. Since the linerboard is homogeneous, no special gluing considerations of corrugated boxes is required at the manufacturing joint (two paper surfaces are glued together) as required with varnished or carbon loaded ESD liners. The exterior linerboards can be printed with a wider variety of ink lettering and images. Since the conductive shielding paperboard is buried under a carbon free linerboard, the material exhibits a superior resistance to rub off of conductive particle or sloughing. It takes a Teledyne Taper® Abrasion Tester 1000 to 1020 cycles of a 1000 gram wheel as it rotates at 70 revolutions per minute to reach the buried homogeneous carbon medium. This is known as the American Standards for Testing Materials (ASTM) D-4046 test method.

Conductive particles do not bridge the gaps of circuit lines or become wedged in an electronic component to cause a spark when a circuit board rubs against a wall of a partitioned container. The existing conductive ink coated technologies have been known to lose 40% to 50% of their conductive particles in 10 cycles of the above test. The most favorable buried layered shielded technologies still have trace elements of carbon in their liners that have a potential for sparking. Because the liner is homogenous, the ESD characteristics are well maintained after severe wear of the other liners since the paperboard is not coated or topically treated. Unlike, surface conductive coated products, this invention does not sacrifice the static shielding after the surface liners become worn, bent or broken at the scorelines. The common practice of removing labels from a box will not make a corrugated container less or dissipative shielding in the event that surface fibers of the outer liners are torn off the face of the box. Major advantage of the invention are reusability, longevity and the fiberboard's ability to perform well in low relative humidities and provide a path to drain a charge to ground. For economic considerations and durability, the homogeneous paperboard can be made into varying basis weights to meet required applications. The variety of color options would offer a customer the ability to purchase the fiberboard in a wide spectrum while meeting ESD or company requirements. Since the liners are layered and are homogeneous, weak internal bonding of the paperboard is not a problem.

SUMMARY OF THE INVENTION

Advantages over previous technologies is that the invention's ESD fiberboard is truly homogeneous for volume resistance and provides an excellent path to ground; it is durable, it has carbon free homogeneous electrically static dissipative liners and is gluable. Moreover, the printing options that can be used greatly outweighs coated or layered carbon linerboard. The versatility of the invention allows it to be made into ESD static shielding boxes, bags, dividers and packaging materials that are completely recyclable. The invention can have a buried shielding fluted medium under homogeneous liners or be laminated into solid fiber. Special CDM safe dissipative readings are exhibited while excellent static shielding takes place. A container made of the invention can sustain wear without affecting its attractive appearance while exhibiting safe static dissipate surface resistance readings per ESD-S.11.11-1993.

The purpose of the invention is to protect electronic components and devices from the hazards of electrostatic discharge. A preferred fiberboard configuration incorporates a buried fluted or unfluted shielding paperboard (less than or equal to 1.0×10^3 ohms per ESD-S.11.11-1993) that has been adhered together through the corrugation process or lamination process with one or more homogeneous colored dissipative high strength liners. The liners have a surface resistance range between a targeted 1.0×10^7 to 1.0×10^{11} ohms at 12% +/-3% relative humidity & 73^0 Fahrenheit. The linerboard or medium can be used as

static safe packaging cushioning material, shelving liners, dividers, in-plant handlers, and specialty static free packaging shielding or dissipative paper bags. Unlike the prior technologies, each individual paperboard component of the fiberboard is homogeneous throughout the material. This unexpected benefit of the invention affords the fiberboard to be volume resistant for effective static decay results. In addition, another surprising benefit is that the homogeneous nature of the paperboard results in a Crypto charge free fiberboard. Unlike the existing layered, laminated and coated linerboards which can exhibit "Crypto" (charges which are hidden) charges or suppressed charges within corrugated linerboard(s), solid fiber and medium. Volume Resistance equals VR=6.9 cm^2 is the AREA of a center electrode (D) that contacts the surface of the material. T= The thickness of the material in centimeters (cm) and R= The Resistance of the material in ohms for test method ESD-S.11.12-1995. Also, since the dissipative liners are truly homogeneous and the medium is conductive, the product is not dependent on higher relative humidities such as 50% to function as materials that use kraft liners on the inside of an ESD shielding container, which experience less than 12% to 15% relative humidity and can exhibit insulative surface resistance readings. The ESD Association requires conditioning for 48 hours at 73^0F @ 12% relative humidity (standard conditions) for testing. Static decay measurements according to EIA-541, Appendix F, should be less than 2.0 seconds at standard conditions for a range of +/-1000 volts to +/-100 volts. The other products may exhibit insulative readings when the relative humidity falls

below 12% to 15% for kraft liner and 23% to 30% for white paper. A conductive medium in combination with one of more homogeneous dissipative linerboard(s) provides an excellent path to ground for the fiberboard invention.

REFERENCE FIG & DRAWING NUMERALS:

DIA 1	machine process illustration for examiner
FIG 1	shielding Human Body Model (HBM) reference only
FIG 2	fiberboard
FIG 2A	cross section of medium, apex & nadir for starching
FIG 2B	cross section of dissipative linerboard
FIG 2C	fiberboard w/conductive medium sheet perspective
FIG 2C1	cross section of solid fiber or liner (33), (35) & (37) as laminated
FIG 2C11	cross section FIG 2C111
FIG 2C111	fiberboard w/o conductive medium sheet perspective
(28)	conductive medium bonding area
(30)	homogeneous carbon black medium
(31)	kraft medium with no dissipative/conductive treatment
FIG 3	front view dissipative solid fiber
FIG 3A	front view dissipative/buried conductive solid fiber
FIG 3A1	perspective of FIG 3A dissipative/buried conductive solid fiber
FIG 3A11	cross sectional of FIG 3A1
FIG 4	crumple use of invention

(32)	adhesive for solid fiber bonding
DIA 1	machine process flow
(33)	buried conductive homogeneous paperboard
(34)	buried solid fiber dissipative linerboard
(35)	exterior dissipative linerboard
(36)	paperboard **(33)** & **(34)** laminated together with a polymer
(37)	optional polymer applied to **(36)**
Ex. 1	ESD specification sheet
(44)	nadir of conductive medium
(46)	apex of conductive medium
(47)	machine that crumples paper rolls/sheets into packaging
(48)	dissipative buried ply linerboard
(49)	dissipative ply filler
(50)	box

DESCRIPTION OF THE INVENTION:

This product can use any recyclable paperboard since the ESD fiberboard (FIG 2 & 2C) or solid fiber (FIG 3 & 3A) are homogeneously admixed with special static enhancing or conductive additives which exhibit static dissipative readings. The invention can be made from a homogeneous manufacturing technology that can use a full array of color options and shades since the paperboard is being chemically treated throughout. This fiberboard can be

manufactured into an A/B/C/D/E/F/N or AB/BC/CB/BB/EF/BE/FE or any combination thereof as flute construction corrugated or solid fiber using 10 pounds through 100 pound per thousand square feet (msf) basis weight. This linerboard **(35)** is combined into corrugated or solid fiber (FIG 2, 2A & 2B, 3A) with a buried homogeneous conductive medium **(30)** (FIG 2A) or conductive paperboard **(33)** (FIG 3A, 3AII) which ranges from 10 lbs./msf to 50 lbs./msf. Per standard ESD-S.11.11-1993, the medium is sufficiently mixed with an electrically conductive material to provide an electrically conductive resistance of less than 1.0×10^3 ohms reading. The inside and outside dissipative liners are adhered to the medium's (FIG 2A) fluting apex **(46)** and nadir **(44)** at opposite ends of each other **(28)** (FIG 2C) via a heat and starching process which bonds the fiberboard together. The homogeneous nature of this ESD paperboard allows for a greater range of basis weights since the material will not be limited by the range of a cylinder machine as to promote score or edge cracking as found with layered or coated ESD corrugated technologies. This invention's ESD fiberboard material is constructed of two of more paperboard liners that are combined through corrugation or lamination. The invention's linerboard is manufactured homogeneously into a special dissipative colored paper admixture of specially formulated ESD imparting chemicals. This paperboard is mixed in a batch with dissipative colored pigments, dyes, Calgon® Polymer Series 261 by 0.5%-7.5% (depending upon resistance required and thickness of paper required) or 1.5% - 6% of Union Carbide's Carbowax (pure polyethylene glycol)

or Witco's Diethanol amide by 1.0% - 7% (depending upon level of required resistance) as mixed into the hydrapulper slurry. This new linerboard can range from 10 lbs./msf to 100 lbs./ msf. The dissipative linerboard color is composed of a powdered color admixture/Calgon® Polymer Series 261 or Carbowax or Diethanol amide/wood fibers or rice paper/starch and adhesives. The conductive shielding medium is imparted with evenly dispersed carbon black and can have a basis weight range between 10 lbs./msf to 50 lbs./msf. Specification and test data were based on the measurements per Electronic Industry Association and ESD Association Standards, NASA, Boeing Aircraft and TAPPI requirements (see Ex. 1).

Other advantages over previous technologies is that this product is truly Homogeneous for volume resistance, provides an excellent path to ground on a grounded surface, superior durability, carbon free liners, gluability and printing options. The invention can be made into ESD static shielding boxes, bags, dividers and packaging materials. The invention comprises a buried shielding linerboard or medium that is laminated or corrugated to the exterior homogeneous linerboard. Again, the unexpected results of the invention are volume resistance that eliminates surpressed charges and promotes an excellent drain to ground while being an effective CDM safe and static shielding product. In addition, it was not anticipated that the exterior linerboard would not need carbon to exhibit static dissipative readings in low relative humidities nor

be free of hidden charges (Crypto) due to the homogeneous nature of the fiberboard.

PHYSICAL COMPOSITION OF ESD INVENTION

The corrugated liner is made of dissipative pigmented colored paper **(35)** (FIG 2, 2B, 2C) sized with a sealer to prevent rub off. A targeted electrical resistance greater than 1.0×10^7 ohms but less than 1.0×10^{10} ohm is desired. This can be achieved by the addition of approximately 10 to 12% by weight of powered colored dissipative dyes with an admixture of carbon free Calgon® Polymer Series 261 or Carbowax or Diethanol Amide in the wood fiber batch or slurry (see reference PTO examiner's Machine Process Flow DIA. 1). The Calgon® Polymer Series 261 shall be the preferred additive due to the environmental friendly nature of the chemical polymer. A mixture including, but not restricted to, wood pulp fiber, recycled news print, rags, construction paper, rice paper, water, dissipative colorants (pigments/dyes or combination thereof) and Calgon® Polymer Series 261 or Carbowax or Diethanol Amide and other chemicals can be used in the ESD paper making process of this invention. The aforementioned are added to a large blender such as a hydrapulper or beater to insure a homogeneous and equal distribution of the raw materials. The raw materials are blended until a homogeneous suspension of wood pulp is achieved. The Calgon® Polymer Serie1qs 261 insures excellent static dissipative readings in very low relative humidities. Henceforth, the linerboard

remains free of carbon. The consistency (% solids) of the mixture varies depending on the requirements per ESD-S.11.11-1993 for the final readings desired. For example, the black homogeneous medium or fluted arches used for corrugation requires at least 8% to 10% carbon black powder to obtain outstanding conductive readings as required for excellent high voltage discharge resistance.

The color of the finished paper is determined by the combination of paperboard mixed into the slurry, the combination of specially formulated dissipative colorants used, the amount of the dissipative colorant used and the dwell time that the colorants have with the pulp. Too little of a time can adversely affect the final readings for meeting the dissipative requirements per ESD-S.11.11-1993. The rapid change in momentum of the hydrapulper insures that the dynamic forces break up the raw materials and insure bonding of the formulation to take place. Dissipative colored homogeneous paper or liners can be attained using the batch method described above or by continuous addition of colorants prior to the formation of the ESD paper. However, the special chemical greatly promotes the dissipative nature of ESD fiberboard invention.

The homogeneous mixture is pumped from the pulper through a series of holding chests prior to being pumped into the paper machine headbox. The number and size of the holding chests vary depending on the particular design

of the paper machine. The headbox uniformly distributes the suspension onto an endless moving screen (wire). The wire and associated equipment forms the fibers into a sheet by enabling the water to drain through the wire. Water drains by gravitational forces and various vacuuming methods, which should employ vacuum air ionization to keep out contaminates. This area of the paper machine is described as the forming area of the paper machine or, more specifically, the forming table of the Fourdrinier paper machine. Formation is the degree of uniformity of the fibers in the finished rolls of dissipative or conductive paper. The wet, but formed continuous sheet or liner, is then fed through a series of presses where additional water is removed and the continuous sheet is compressed. The majority of the remaining water is evaporated as the sheet contacts a series of steam heated cylinders called dryer cans. The dryer section of the paper machine is comprised of two sections separated by a piece of equipment known as a size press. The size press is used to add various surface sizes for the specially formulated dissipative and conductive ESD liners. The continuous sheet or liner of paper exits the size press and enters the last section of dryers where final drying of the paper takes place.

Upon exiting the last section of dryers, the continuous sheet of paper passes through the calendar stack. The level of calendering is determined by the roughness or smoothness required for the paperboard. The more the continuous sheet is calendered, the denser and smoother the sheet becomes.

The finished liner is rewound, slit and measured for ESD readings for the special ESD liners. The ESD fiberboard material will be made into protective sheeting for use in the packaging of electrostatically sensitive devices. The novel method comprises the steps of providing a homogeneous carbon loaded paperboard medium in continuous roll form which has an electrical resistance of the surface that measures less than 1.0×10^3 ohms, providing homogeneous continuous rolled liners with various electrostatically dissipative admixtures of colored dyes and batching the homogeneous mixture as described earlier to obtain surface resistance readings between 1.0×10^5 to 1.0×10^{11} ohms at less than standard conditions for the static dissipative colored liners.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

These and other features, advantages and improvements of the invention will be understood from the following detailed description of the preferred embodiments as illustrated in the accompanying drawings. The reference Fig 1. shows one main function of an ESD box with an event detector by 3M® Company placed into the closed box a grounded plane. The box is subjected to a 1000 volts or greater discharge. The ESD event detector by 3M® will change from clear blue or red in color if the voltage is not shielded from entrance into the box. The ESD paperboard homogenous medium is carbon loaded and is adhered to the adjacent colored homogeneous dissipative high strength linerboard. This is fully in view per the samples of actual colored dissipative

homogeneous liners and medium(s) before the bonding process has taken place (see Fig 2B). Heat and starch cause the top **(46)** and bottom **(44)** of the medium to bond **(28)** (FIG 2C) to the underside of the linerboard. The colored static dissipative linerboard as per the **(35)** (FIG 2 , 2B & 2C). The linerboard can be made up of wood pulp, fiber, water, dissipative color(s) & or dyes, pigments, Calgon® Polymer Series 261 or Carbowax or Diethanol Amide & other chemicals to impart a preferred static dissipative resistance reading between 1.0×10^{7} - 1.0×10^{11} ohms at standard conditions. The conductive medium(s) (numbered **(30)** of FIG 2, 2A & 2C is buried between one or more dissipative linerboards. Again, the color of the finished paper is determined by the combination of fibers used, the combination of specially formulated dissipative colorants used, the amount of the dissipative colorant used and the dwell time the colorants have with the pulp. Too little time can adversely affect the final readings for meeting the dissipative requirements per ESD-S.11.11-1993. The corrugated conductive medium, as illustrated in cross section of mediums has a wave-like shape known as flutes **30** (FIG 2A & 2C). The medium can have a basis weight of 10 lbs./msf to 50 lbs./msf. The conventional weight is about (+/-) 26 lbs./msf for corrugated medium. The conductive medium section view FIG 2A can be targeted between 18 lbs./msf to 50 lbs./msf. The corrugated medium is made up of paperboard that has been mixed into a batch with water and carbon black to achieve a surface resistance of less than 1.0×10^{3} ohms per ESD-S.11.11-1193. This can be achieved by admixing approximately 6% to

10% by weight of carbon black powder into the paper pulp in the manufacture of ESD roll stock medium.

The rolls can then be shipped to a corrugated box plant and corrugated into boxes. The advantage is superior graphics and reduced print crush versus a coated process utilized in the ESD corrugated industry which hinders printing. The substrate medium shall be of either a recycled composition of paperboard with no less than 6% to 10% conductive carbon powder to obtain a reading of less than or equal to 1.0×10^3 ohms.

The ESD liner shall contain less than 8 PPM of reducible sulfur and have static dissipative reading of less than 1.0×10^{11} ohms as a measurement in resistance at less than a targeted range between 4% through 12% relative humidity. The liners shall be corrugated or laminated and provide the exterior of the package or surface of the ESD paper product(s). In corrugation, the high strength linerboard shall be opposite each other during corrugation. The basic advantages of the more elaborate preferred form of the present ESD fiberboard are retained in a continuously buried shielded medium **(30)** which provides Faraday Cage shielding and a slower drain to ground due to the dissipative colored liners **(35)** (FIG 2, 2B & 2C). Conductive surfaces drain charges too quickly and cause "sparking" or "rapid" discharges" when a grounded operator touches an ungrounded open container which is known as a Charged Device

Model hazard. The lamination of the buried conductive paperboard **(33)** can be adhered **(32)** to a dissipative colored homogenous dissipative paperboard **(35)** to form a linerboard which can be corrugated to a conductivity homogeneous medium (30) or a non treated buried kraft colored medium **(28)** to form an alternative ESD corrugated sheet as illustrated in FIG 2C111 and cross section FIG 2C11. The paperboard **(36)** (FIG 2C1) can be laminated with a homogeneously conductive paperboard **(33)**, static dissipative paperboard **(35)** with an adhesive **(32)** and a polymer film or finish **(37)**.

The potential of conductive particle sloughing or rub off is substantially reduced since the paperboard liners are static dissipative. This is a very hazardous problem since the pins of a circuit board can rub up against coated or carbon loaded dividers or partitions. Conductive carbon particles can bridge the gap of circuit lines and cause a short. ASTM D-4060 test method is achieved by a 1000 gram wheel rotating at a rate of 70 RPMs that will cause a surface coated conductive liner to lose conductive particles in 10 cycles or less. In this invention, the static dissipative linerboard would not exhibit any conductive particle rub off until it wears entirely through the surface of the linerboard into the homogeneous conductive paperboard **(33)** or medium **(30)**. The linerboard can be laminated onto dissipative plies **(34, 35)** of solid fiber to form a rigid non-fluted durable material (FIG 3) on the attached illustration. The solid fiber (FIG 3) could be used as dividers requiring no shielding but exhibiting dissipative

properties or have a homogeneous shielded **(33)** (FIG 3A) paperboard linerboard adhered between dissipative exterior liners **(35)** and made into non fluted containers or boxes, mailers, bags or shelf liners or mats for static shielding, or a means for draining a charge to ground. The paperboard could include corrugated cuttings/clippings, virgin pulp or fiber, rags, rice paper, newspaper material, construction paper and other paper products.

The FIG 4 illustration shows ESD dissipative liner **(48)** or black conductive paperboard **(33)** liner being crumpled up and free falling **(49)** into an open container **(50)**. If one took a sheet of paper and crushed it with one's hand into a "snow ball-like" shape, it would emulate the process taking place with the liner. A dozen 8" x 11" paper sheets crushed into a snow ball like shape would be a good cushioning material. The ESD paperboard is recyclable and repulpable. It exhibits static dissipative or conductive readings.

The test results as illustrated in the "Material Specifications" (see Ex. 1) were conducted to establish the properties relevant to electrostatic protection. An article has appeared in the March 1997 issue of "***Packaging Technology & Engineering***" as written by the inventor, Robert J. Vermillion, CPP & Certified, ESD Engineer, NARTE.

EXAMPLE 1

MATERIAL SPECIFICATIONS

STATIC DECAY:

- I. Standard: Rate of decay shall be less than 2.0 seconds
- II. Results: Average 0.4 seconds @ 12% RH 73^0 F
- III. Method: EIA-541, Appendix F, +/-1kv to +/-100v

SURFACE RESISTANCE IN OHMS:

- I. Standard: Less than 1.0×10^{11} ohms
- II. Results: 5.3×10^6 ohms - 4.5×10^9 ohms
- III. SHIELDING MEDIUM:
- IV. Results: 4.3×10^2 ohms - 5.2×10^3 ohms
- V. Method: EOS/ESD S11.11-1993 @ 12% RH 73^0 F

VOLUME RESISTANCE IN OHMS-CM.

- I. Standard: Less than 1.0×10^{11} ohms-cm
- II. Results: 5.3×10^6 ohms-cm
- III. Method: EOS/ESD S11.12-1995 (PROPOSED) @ 12% RH 73^0 F

STATIC SHIELDING:

- I. Requirement: Integrity of 3M Sensor @ 100 Volts for 4kv & 10kv
- II. Results: Passed 4kv & 10kv
- III. Method: 3M 753-ESD Simulator Unit & 3M Sensors
  Meets EIA-541, appendix E, Capacitive Probe Test

RECYCLABILITY:

- I. Requirement: 100% recyclability to recycling centers
- II. Results: Requirement Met
- III. Reference: PAPER REPULPING TESTS-JUNE 1996

CDM SAFETY:

- I. Requirement: Pass 3M Static Event Detector of 87 volts @ 1kv
- II. Results: Passed 10kv to 3M Event Detector of 50 volts
- III. Requirement: Dr. John Kolyer Method, Boeing Aircraft Oct. 1991

CHEMICAL:

- I. Requirement: <8 PPM (parts per million)
- II. Found: Reducible Sulfur: 3 PPM
- III. Reference: Nontarnishing to silver, solder & copper per Tappi T-406

TRIOBOELECTRIC CHARGING:

- I. Requirement: MEETS NASA REQUIREMENT
- II. Results: REQUIREMENT MET
- III. Reference: MMA-1985-79-REV 2 JULY 15, 1988 RH GOMPF, PE, Ph.D. NASA & C.L. SPRINGFIELD, NASA CHIEF MATERIALS TESTING BRANCH.

The preferred embodiments of this invention have been specifically described and illustrated to demonstrate its novel features that produce new and unexpected results. It is foreseeable that a person having ordinary skill in the art will envision substitutions, modifications, and changes to the invention's described embodiments, which are within the parameters of the present invention as defined by the following claims.

CLAIMS

1. Fiberboard for use in protecting electrostatically sensitive devices against the hazards of electrostatic discharge, said fiberboard being characterised by

    (a) A homogeneous conductive layer formed from paperboard or other suitable material sandwiched between juxtaposed first and second faces of static dissipative linerboard, said paperboard layer having an electrically conductive substance substantially homogeneously admixed therein to impart electrical conductivity to said layer, and

    (b) Said opposite first and second faces of static dissipative linerboard having a static dissipative substance substantially homogeneously admixed therein to impart to said linerboard a static dissipative property.

2. The fiberboard in claim 1 wherein said substantially homogeneous conductive paperboard has an electrical resistance equal to or less than ten to the third power ohms.

3. The fiberboard in claim 1 wherein said substantially homogeneous static dissipative linerboard has an electrical resistance between ten to the fourth power and ten to the eleventh power ohms at a relative humidity of less than twelve percent.

4. The fiberboard of any preceding claim wherein said sandwiched substantially homogeneous conductive paperboard is a wave shaped layer, pressed into corrugation with apexes and nadirs in an alternating fashion according to the Fiber Box Handbook as A, B, C, D, E, F,N, BC, CB, BB, BE, EF, AB, BA AND BF flute of corrugated liners.

5. The fiberboard of any preceding claim wherein said substantially homogeneous static dissipative linerboard further includes trace amounts of substantially homogeneously distributed carbon powder in dissipative ink.

6. The fiberboard of any preceding claim wherein said substantially homogeneous static dissipative linerboard contains no less than about one and one-half percent of a substantially homogeneously distributed inherently static dissipative substance, diethanolamide.

7. The fiberboard according to claim 6 wherein said static dissipative substance is diethanol amide or polyethylene glycol.

8. The fiberboard according to claim 6 or claim 7 wherein said homogeneous static dissipative linerboard further includes trace elements

of metal content in dissipative pigments.

9. The fiberboard according to any claims 6 to 8 wherein said substantially homogeneous static dissipative linerboard further includes a homogeneously distributed inherently static dissipative paper process custom polymer, Calgon® 261, in an amount between one-half and seven percent and one-half percent.

10. The fiberboard according to any of the preceding claims wherein said sandwiched substantially homogeneous conductive paperboard further includes no less than about five and one-half percent of a homogeneously admixed electrically conductive substance.

11. Static dissipative paperboard for use to package electrostatically sensitive devices, said paperboard comprising:

(a) a static dissipative substance substantially homogeneously admixed to impart to said paperboard a static dissipative property with an electrical resistance between ten to the fourth power and ten to the eleventh power ohms at a relative humidity of less than or equal to 12 percent.

12. The static dissipative paperboard according to claim 11 wherein said

substantially homogeneous static dissipative paperboard further includes a homogeneously distributed inherently static dissipative substance in an amount no less than about one and one-half percent.

13. The static dissipative paperboard according to claim 12 wherein said static dissipative substance is polyethylene glycol or diethanol amide.

14. The static dissipative paperboard according to any of claims 11 to 13 wherein said substantially homogeneous static dissipative paperboard further includes a homogeneously distributed inherently static dissipative paper process custom polymer, such as Calgon® 261, in an amount between one-half and seven and one-half percent.

15. The static dissipative paperboard according to any of claims 11 to 14 wherein said substantially homogeneous static dissipative paperboard further includes a homogeneously distributed inherently static dissipative trace amounts of metal content, dissipative pigment.

16. The paperboard according to any of claims 11 to 15 wherein said static dissipative paperboard is adhered to a conductive paperboard on an exposed face thereof.

17. The paperboard according to claim 16 wherein said conductive paperboard has a protective finish applied to said exposed face, to mitigate against sloughing and wear of said conductive paperboard.

18. A method for making recyclable fiberboard for use in protecting electrostatically sensitive devices from the hazards of electrostatic discharge which method comprises the steps of:

(a) providing a homogeneous carbon black paperboard layer in continuous roll form which is of wave shape construction having an electrical resistance of less than or equal to ten to the third power ohms;

(b) providing linerboard that comprises electrically dissipative substances in predetermined amounts into a homogeneous admixture to obtain a dissipative electrical resistance of between ten to the fourth power and ten to the eleventh power ohms at twelve percent relative humidity;

(c) gluing each linerboard to the wave like homogeneous conductive medium through a heat and starching process so that each linerboard is adhered to the apexes and nadirs of the corrugated layer, whereby a fiberboard with dissipative and shielding properties.

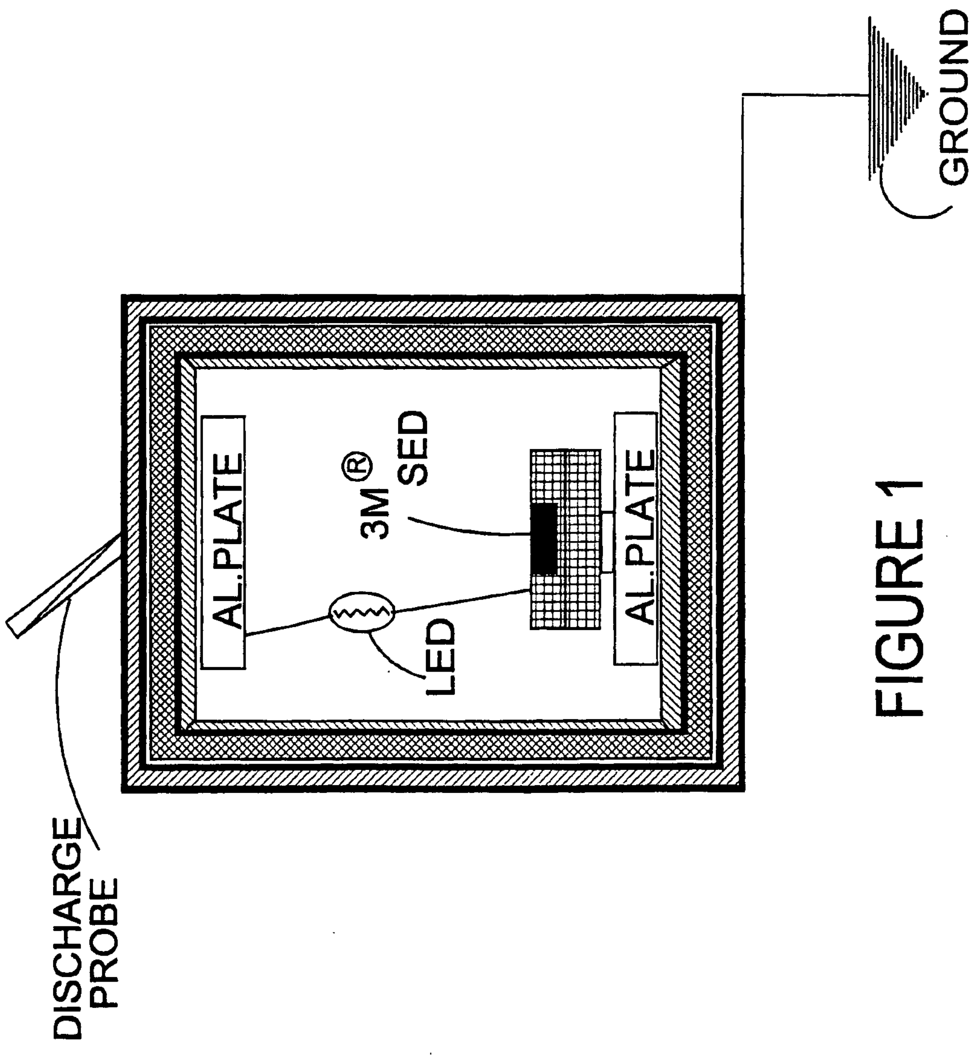


FIGURE 1

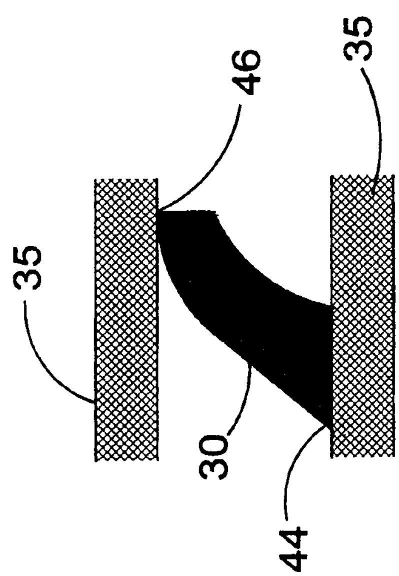


FIGURE 2a

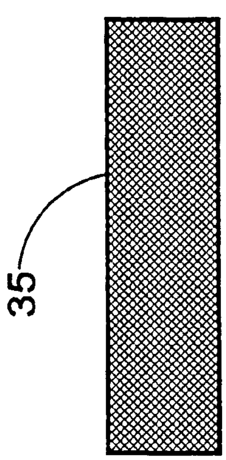


FIGURE 2b

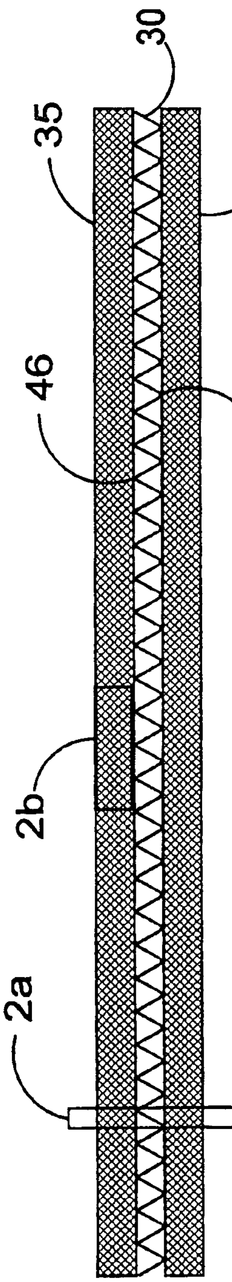


FIGURE 2

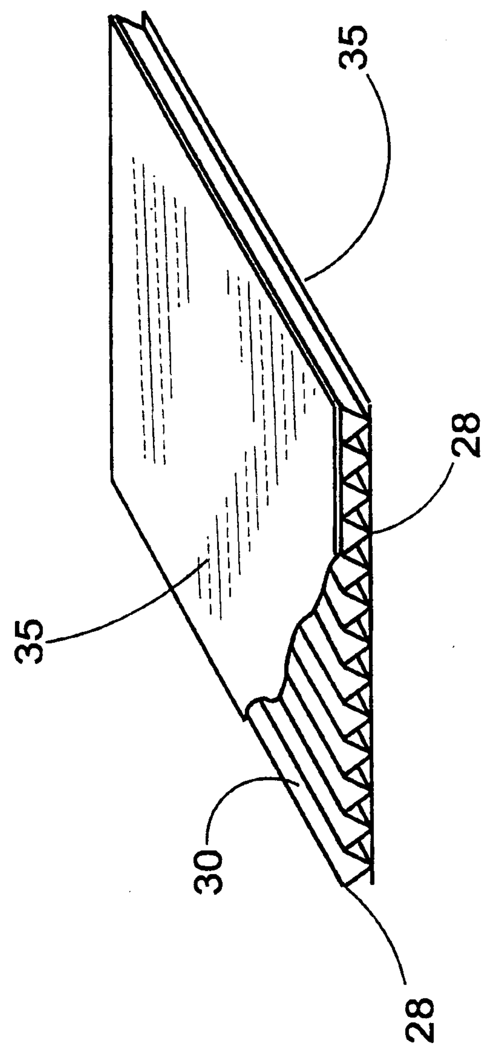


FIGURE 2c

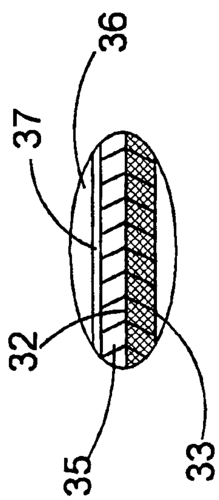


FIGURE 2cI

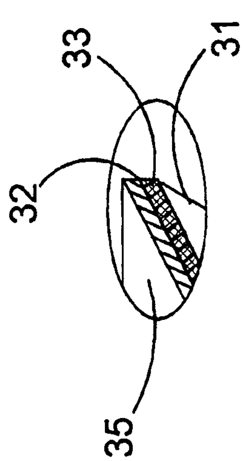


FIGURE 2cII

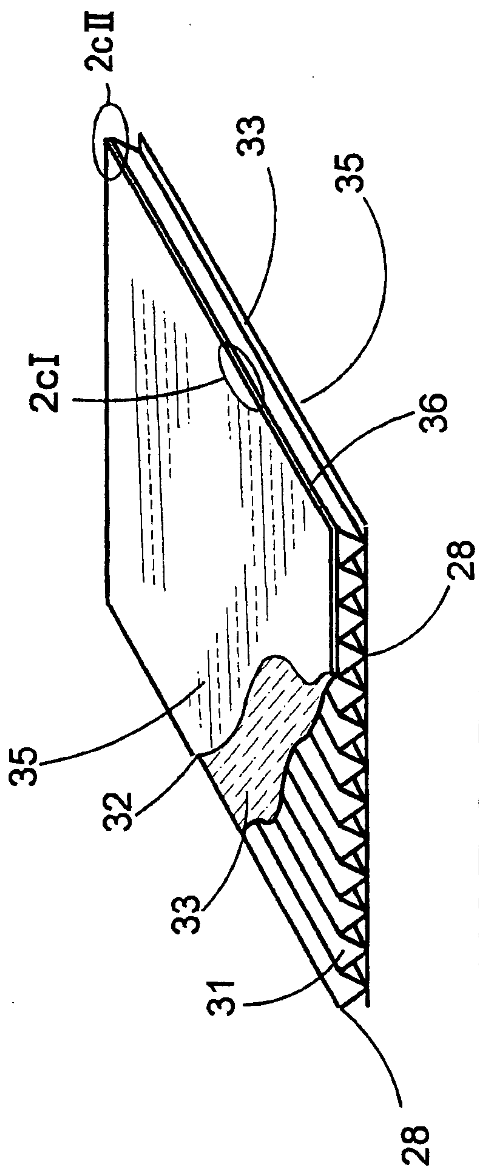


FIGURE 2cIII

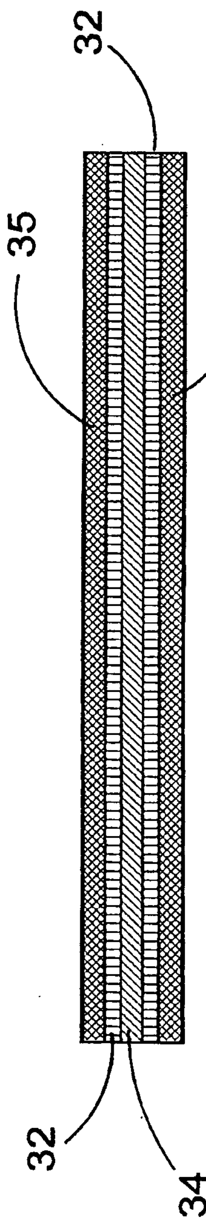


FIGURE 3

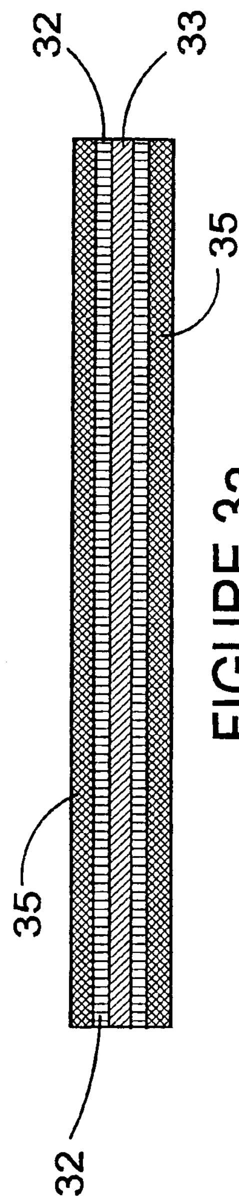


FIGURE 3a

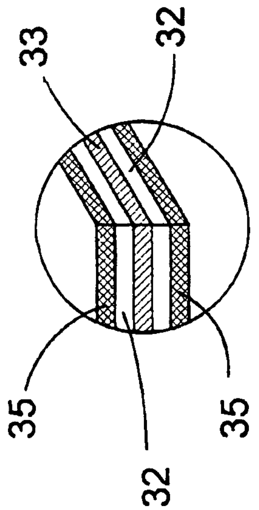


FIGURE 3aII

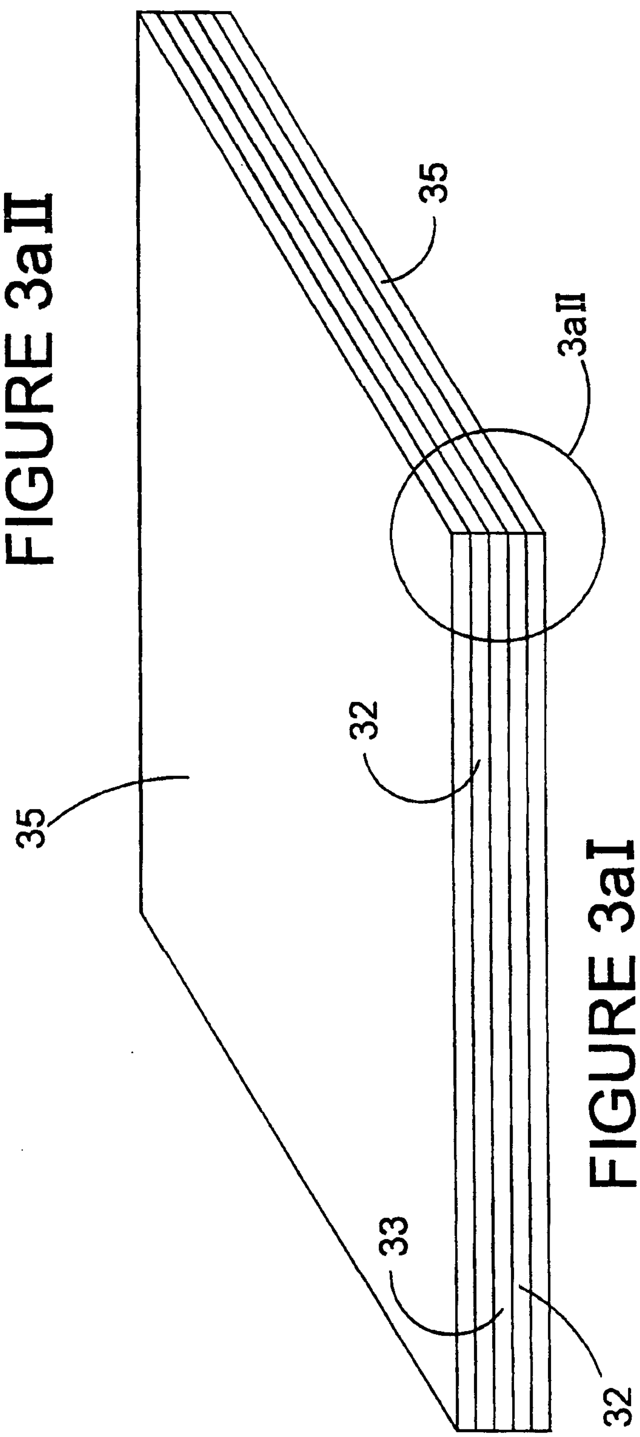


FIGURE 3aI

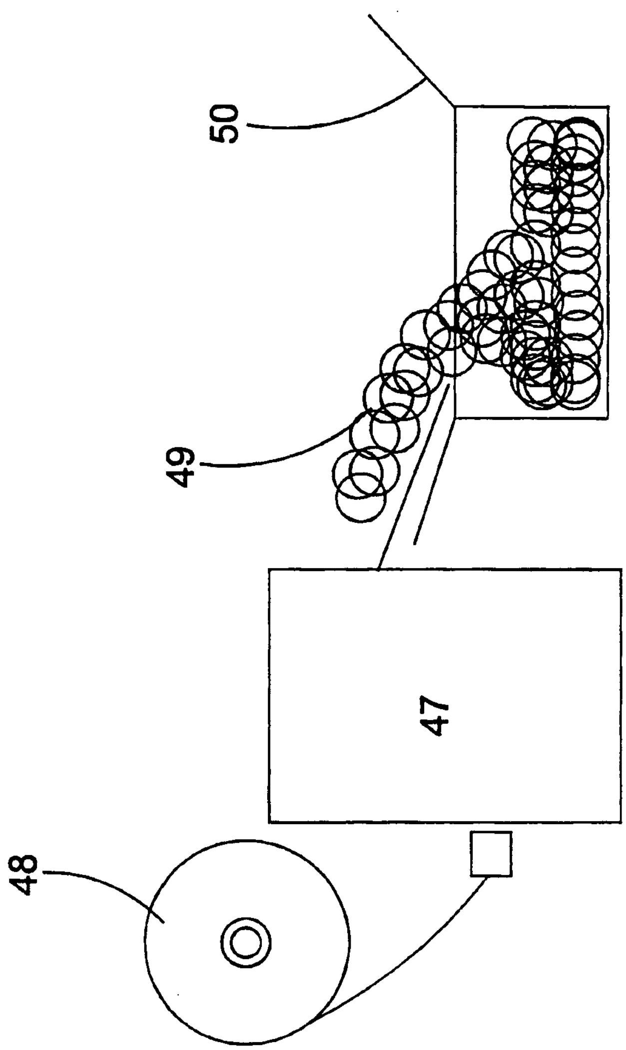
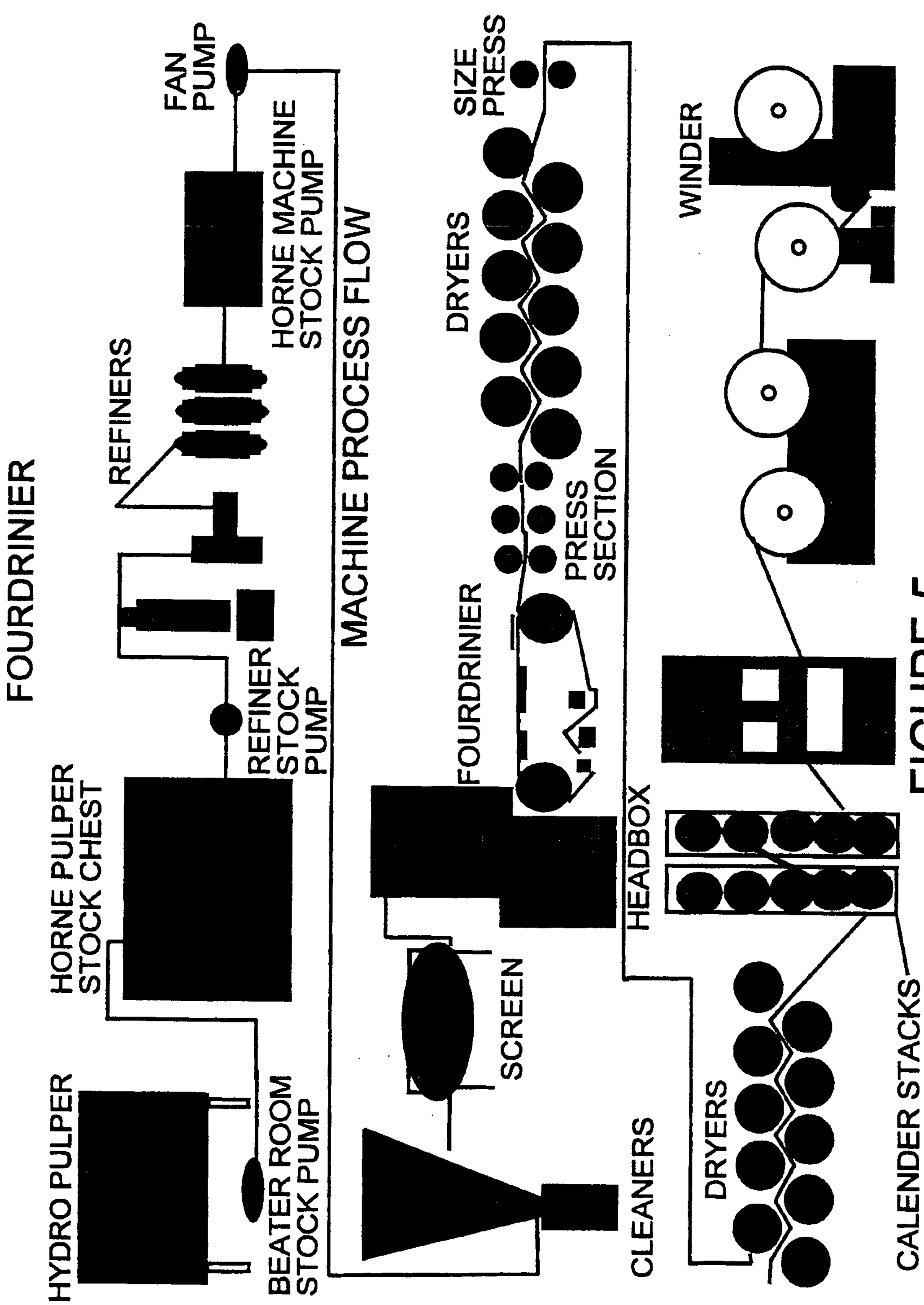


FIGURE 4



FOURDRINIER
HYDRO PULPER
BEATER ROOM STOCK PUMP
HORNE PULPER STOCK CHEST
REFINER STOCK PUMP
REFINERS
HORNE MACHINE STOCK PUMP
FAN PUMP
MACHINE PROCESS FLOW
CLEANERS
SCREEN
HEADBOX
FOURDRINIER
PRESS SECTION
DRYERS
SIZE PRESS
DRYERS
CALENDER STACKS
WINDER

FIGURE 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 98/02003

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B32B29/00 H05K9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B32B H05K H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 966 280 A (BRADFORD JUDSON A) 30 October 1990 see claims 11,12,17 see column 3, line 62 - column 4, line 8 see column 4, line 16 - column 4, line 25	1-3,11, 16
A	see column 5, line 50 - line 66 see column 6, line 23 - line 32 ---	4-10, 12-15, 17,18
X	US 4 909 901 A (MCALLISTER RICHARD G ET AL) 20 March 1990 see claims 1,2 see column 2, line 50 - line 59 see column 3, line 29 - line 39	1-3,10, 11,16
A	see column 3, line 44 - column 4, line 8 ---	4-9, 12-15, 17,18

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 March 1999	18/03/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Girard, S

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inte..ational Application No
PCT/IB 98/02003

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 637 377 A (VERMILLION BOB) 10 June 1997 cited in the application see claims 1-6,26 see column 4, line 33 - line 40 see column 5, line 42 - line 58 see column 6, line 37 - line 53 -----	1-18

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte..ational Application No
PCT/IB 98/02003

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
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			US	5205406 A	27-04-1993
US 4909901	A	20-03-1990	NONE		
US 5637377	A	10-06-1997	NONE		